LANL announces Top 10 science & technology developments of 2010

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LOS ALAMOS, New Mexico, December 20, 2010—Los Alamos National Laboratory has named its Top 10 science and technology developments of 2010 based on major programmatic milestones, strategic potential, scholarly accounts, and associated news coverage.

“The science featured here represents just a fraction of what we the Laboratory accomplished this year. But it does indicate the extreme breadth of national security science work we do here at the Lab as well as the high caliber and dedication of people at Los Alamos in service to our nation,” said Terry Wallace, LANL’s principal associate director for science, technology, and engineering. “This year’s compilation ranges from achievements in HIV vaccine research and airport security to stockpile stewardship and biofuels advancement.”

Much of the science and technology at Los Alamos stems from or benefits the Lab's key national security mission performed for the National Nuclear Security Administration (NNSA).

"I continue to be impressed by the contributions this lab makes to improve the health and the quality of life of people around the world," said Kevin Smith, manager of NNSA's Los Alamos Site Office. "We are very proud of the LANL men and women behind these accomplishments."

The Top 10 LANL science and technology developments of 2010:

Developing a novel HIV vaccine

Using the Lab's Roadrunner supercomputer, LANL scientists created the world's largest evolutionary tree for HIV, the virus that causes AIDS. Working as part of a consortium led by Duke University Medical Center, LANL researchers used this data to help design a new type of vaccine that's progressing to human clinical trials. The consortium's biometric mosaic vaccine approach benefits from computational methods developed at LANL to create sets of highly variable artificial viral proteins. In combination, these proteins provide nearly optimal coverage of HIV's diverse forms. Studies have shown that the mosaic vaccination strategy expands the breadth and depth of immune responses in rhesus monkeys, the best animal model available.

Advancing a liquid scanner system for use at airports

Los Alamos scientists successfully demonstrated in October a new version of the Lab's magnetic resonance scanner designed to characterize potentially explosive liquids and gels in bottles and cans. The device, called CoilViz, provides results in under 30 seconds, displaying a simple red-yellow-green light signal. The new prototype is smaller, faster, technologically simpler, and cheaper to produce than its predecessor, adapted from MRI medical technology. Last year's LANL Top 10 list included the earlier MagViz prototype, developed, like its successor, for the U.S. Department of Homeland Security.

Creating unprecedented imaging capabilities for stewardship of the nation's nuclear weapons stockpile and other applications

Lab staff this past year won five R&D 100 awards from *R&D Magazine*. One went to Scott Watson, inventor of the world's fastest and most flexible movie camera, MOXIE, which captures 20 million frames per second. MOXIE, which stands for Movies of eXtreme Imaging Experiments, can record images from visible light, X-rays, gamma rays, and neutron sources. Because each of MOXIE's pixels has its own detector, amplifier, analog-to-digital convertor, and memory—with thousands of channels operating in parallel—MOXIE achieves high frame rates, a large number of frames, and unprecedented sensitivity required to achieve imaging experiments that other cameras cannot. LANL already uses MOXIE for a wide variety of purposes, which include:

- taking X-ray movies of full-scale mock explosions at LANL's DARHT facility (which made LANL's 2009 Top 10 list), used to verify calculations and certify nuclear weapons without nuclear testing
- better enabling scientists to study material equations of state, fusion plasma, discharge formation, shock physics, and fracture mechanics
- improving the range of experiments using schlieren photography, X-
- ray fluoroscopy, neutron radiography, proton radiography, and visible light photography

- recording detailed movies of detonating improvised explosive devices and facilitating ballistic studies.

Taking advantage of MOXIE, LANL technical staff this year conducted experiments at DARHT (the Lab's Dual-Axis Radiographic Hydrodynamic Test Facility) that greatly benefited the national's Stockpile Stewardship Program. Inside a containment vessel at DARHT, high explosives drive an implosion of a warhead duplicate made from non-nuclear surrogate materials. Two electron accelerators positioned 90 degrees from one another generate high-powered X-rays that yield multiple images of the imploding device's inner workings, which are then compared with computer predictions.

Challenging conventional wisdom about solar wind—a new take on existing data

Research published this year by LANL's Joseph Borovsky indicated that the world scientific community may be fundamentally wrong about the behavior of solar wind—the plasma particles flowing from the sun and blasting past Earth. Borovsky determined that solar wind seems more likely configured as a network of tubes rather than a relatively simple stream of uniform structure. Understanding solar wind allows us to better understand geomagnetic storms, which can damage electrical power grids, satellites, and cell phone transmission.

Making radio waves travel faster than light

A Los Alamos researcher's perturbation of radio waves has made them travel faster than the speed of light—perhaps explaining the mysterious behavior of pulsars in the process. Using a polarizing synchrotron to combine radio waves with a rapidly spinning magnetic field, LANL's John Singleton developed a mechanism that could explain why radio emissions from pulsars are so bright and travel so far through space. (Pulsars are rapidly rotating neutron stars that emit radio waves in regular pulses.) At the same time, he may have discovered a new avenue for super-fast data transmission that could revolutionize medicine and the communications industry.

Boosting output for nuclear physics experiments by 240 percent with a new spallation target scheme

The new target-moderator-reflector system at LANSCE (Los Alamos Neutron Science Center) is producing 20 percent higher neutron (long-wavelength) flux than even the doubling predicted by numerical simulations. The increased flux at LANSCE's Lujan Center enables scientists from LANL and users from around the world to conduct physics experiments on longer scales of both wavelength and time. The third-generation system consists of tungsten targets and a series of moderators, reflectors, and flight paths that deliver neutrons of specified energies and fluxes to surrounding experiments and detector stations. Thanks to its recent redesign, the cold-neutron flux source rivals the highest power-pulsed spallation sources in the world while using just 10 percent of the Lujan Center's proton beam power.

Shedding new light on climate change

Findings by LANL scientists illuminated two major facets of climate change. One group analyzed a century's worth of temperature records from around the world to distinguish human-induced warming from natural variability. They discovered an alternating pattern in 20th-century warming trends of the Arctic and Antarctic Oceans. Their findings suggest that the Atlantic redistributes the heat between the poles. Scientists think that the natural Arctic warming is in phase with the anthropogenic global warming, thus amplifying warming effects.

Another group of LANL researchers examined the release of methane from beneath melting ice and its effect on oceanic oxygen levels. In fact, methane is a much more powerful greenhouse gas than carbon dioxide. Not only could the release of methane dramatically affect rates of warming, but methane could turn certain ocean regions into “dead zones.”

Learning to design stronger materials better suited for use in generating nuclear energy

Los Alamos scientists advanced the base of knowledge required to develop the next generation of structural materials that have ultra-high flow strength, high deformability, and enhanced ability to withstand highly radioactive environments. Experts at the Lab designed, at the nanoscale, multilayered composites that exhibit these desirable properties. Simply put, they documented the mechanics of building quantities of metals, a few atoms at a time, layer by nanoscale layer, such that the resulting material is much stronger than the same substance created by conventional means. In a related development, other LANL scientists reported a surprising mechanism that allows nanocrystalline materials to heal themselves after suffering radiation-induced damage.

Gaining insight to more efficiently convert plant biomass into biofuels

LANL scientists and University of New Mexico collaborators discovered chinks in the armor of lignin, the component of plant cell walls that stubbornly protects cellulose from hydrolyzing enzymes and therefore regulates the early stages of fermentation-based ethanol production. It is hydrolysis—an enzyme-catalyzed bond-breaking process—that converts cellulose to glucose, a base material for fermentation. After synthesizing small fragments of lignin to study them in great detail, the researchers subjected the fragments to chemical, photochemical, and specialized oxidation processes and ran sophisticated quantum mechanical calculations. They found that particular types of chemical linkages were more readily broken than others. The next challenge is to genetically engineer plants that biosynthesize a variant form of lignin that contains more of the weaker linkages, thus making it more cost- and energy-efficient for biomass batch processing.

Developing transparent light-harvesting materials

Scientists at Los Alamos and Brookhaven National Laboratories have fabricated transparent thin films capable of absorbing light and generating electric charge over a relatively large area. The semiconducting polymer material could be used to develop transparent solar panels or new types of optical displays. The method of depositing this film is potentially scalable to industrial size.